



Bayer MaterialScience

UV-A Curable Aerospace Topcoats

Todd Williams

Mike Gallagher

Alan Bushmire

Katrina Callen

Government Services

Mike Dvorchak

Chuck Gambino

Coatings, Adhesives, and Specialties

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UV-A Coatings Characteristics

Advantages

- **Faster cure**
- Storage stable
- One component
- Low VOC

Challenges

- Limited raw materials
- Shadow areas
- Low gloss coatings

■ Drivers

- Dry-to-fly time
- Reduced Waste
- VOC

UV-A Coatings Site Applied

- Automotive refinish
- Headlight refinish
- Site applied flooring
- Aircraft stencils / small area repair



Auto Refinish



Headlight Refinish



Site Applied Flooring



Aircraft Stencil



Previous Work – Stencil Coating

- Chuck Gambino formulated black UV curable stencil coating for aircraft ('07)
- Evaluated by CTIO
 - Reduce gloss
 - Increase flexibility
 - Match color (Deft)



Weathering of UV-A Stencil Coatings on C-130

Coating	ΔE 7 months	ΔE 14 months	$\Delta 60^\circ$ Gloss 7 months	$\Delta 60^\circ$ Gloss 14 months
Black UV Stencil	1.56	0.87	(-5.2)	(-4.8)
2K Gray Fluorourethane (APC)	0.57	1.23	(-0.13)	0.00

- ΔE reduction in UV coatings most likely due to self cleaning – reduced film thickness over time
- Fluorourethane better with gloss retention

Critical Military Specs for Topcoat

- Closest coating from battery of comm. available coatings

Test	MIL-PRF-85285 Spec.	Stencil Coating
GE Impact Test	40%	2%
Chemical Resistance	Jet fuel, hydraulic fluid, and oil	Pass
Crosshatch / Wet tape Adhesion	≥4B	Pass
Gloss	85° ≤ 9 60° < 5	85° - 39
Accelerated Weathering	ΔE < 1 after 500 hrs.	0.9
Color	ΔE < 1 from standard	3.4

Expected UV Coatings Properties

Test	MIL-PRF 85285 Specification	Typical UV Coating
GE Impact Test	40%	--
Chemical Resistance	Jet fuel, hydraulic fluid, and motor oil	++
Dry Adhesion	$\geq 4B$	++
Gloss	$85^\circ \leq 9$	--
Weathering at	$\Delta E < 1$	++
500 hrs	$85^\circ \text{ Gloss} \leq 9$	++
Humidity Resistance	30 days 100% RH at 120 °F	++
Wet Adhesion	$\geq 4A$	++
Color	$\Delta E < 1$ from standard	--



UV Aerospace Team

ESTCP Principal Investigator
Glenn Baker



Program Management

Tom Naguy
Randy Straw (*CTC*)



CTC

Matthew Campbell, *CTC* Project Manager
Anthony Kingera, Technical Support
Steve Finley, Technical Support



**Coatings Technology
Integration Office (CTIO)
Lab Testing**



Principal Stakeholders

Ogden Air Logistics Center
Oklahoma City Air Logistics Center
Warner Robins Air Logistics Center
NAVAIR Depot Jacksonville
USCG Aircraft Repair and Supply Center



Subcontractor

Bayer Material Science/Deft



Bayer **MaterialScience**



Overall Approach

- Formulate coatings that meet MIL-PRF-85285
- Validate coating's performance
- Demonstrate application and validate performance
 - Simple geometry parts
 - Aircraft markings
- Transition technology to end users

UV-A Light

- Currently using H & S Autoshot 1200W
- Dual heads allow cure 3 ft.²
- Only UV-A and IR emitted
- Coating cures in minutes
- Currently no explosion proof light available
- Explosion proof light is feasible



Coating Formulation Project Goals

- Develop UV curable coatings formulations that meet MIL-PRF-85285
- Flat topcoats
 - 37038 international black
 - 36173 neutral gray
 - 36118 gunship gray
- Gloss white topcoats
 - 17925 Air Force white
 - 17860 Coast Guard white

Critical Tests	85285 Specification
GE Impact Test	40% or 60%
Chemical Resistance	Jet fuel, hydraulic fluid, and motor oil
Dry Adhesion	≥ 4B
Low Gloss	60° ≤ 9
Weathering at 500 hours	$\Delta E < 1$ at 500 hrs. 60°Gloss <5 or > 80
Humidity Resistance	30 days 100% RH at 120 °F
Wet Adhesion	≥ 4A
Color	$\Delta E < 1$ from standard



Deft Color Matching

- Color standard based on carbon black
- Black iron oxide ca. four units to light
- Deft identified a mixed oxides pigment closer to carbon black
- Deft also color matched two grays
 - 36118
 - 36173
- Color matched coatings evaluated by Battelle

Properties of Color Matched Coatings (Battelle's Evaluation)

Test	85285 Spec	37038 Black	36173 Gray	36118 Gray
GE Impact Test	≥ 40%	40%	20%	10-20%
Dry / Wet Adhesion	≥ 4B / 4A	5B / 3A	3B / 2A	4B / 4A
Gloss	85° ≤ 9	12	10	8
Accelerated Weathering ΔE at 500hrs	< 1.0	0.99	2.8	1.0
Color ΔE from Standard	< 1	0.9	0.9	10.1
Initial Pencil Hardness	≥ 2B	2H to 3H	3H	H to 2H
Mobil Jet Oil	-2 pencils	-2 to -3	-3	-1 to -2
Hydraulic Fluid	-2 pencils	-1 to -3	-2	-1 to -3
JP-8 Jet Fuel	-2 pencils	-1 to -2	-6	-4 to -6

Properties of Color Matched Coatings (Battelle's Evaluation)

Test	85285D Spec	37038 Black	36173 Gray	36118 Gray
Contrast Ratio	$\geq 95\%$	Pass	Pass	Pass
MEK Resistance	> 25 Double Rubs	Pass	Pass	Pass
Cold Flexibility	-51°C, 2" Mandrel	Pass	Pass	Pass
Heat Resistance	$\Delta E < 1$	0.2	0.9	0.30
Humidity Resistance	30 Days	Pass	Fail	Fail

- Qualified controls did not pass flexibility requirement (?)
- Results variability from coating's cure energy requirements
- Black coating most successful
- Gray coatings least successful

Gloss White Coatings

Waterborne UV (UV-PUD) Coatings

Typical Formulation

- UV Curable PUD
- Photoinitiator
- Pigments
- Cosolvents
- Additives

Typical Challenges

- Application issues
 - Temperature
 - Humidity
- Water sensitivity
- Limited raw materials



Gloss White Coatings Properties

Test	85285 Spec	UV-PUD Coating
GE Impact Test	$\geq 60\%$	60%
Dry / Wet Adhesion	$\geq 4B / 4A$	4B / 4A
Gloss	$60^\circ \geq 90$	80
Initial Pencil Hardness	$\geq 2B$	HB/F
Mobil Jet Oil	-2 pencils	-1
Hydraulic Fluid	-2 pencils	-1
JP-8 Jet Fuel	-2 pencils	-2
Humidity Resistance after 14 days ambient	30 days	No blisters



UV Aerospace Coatings Conclusions

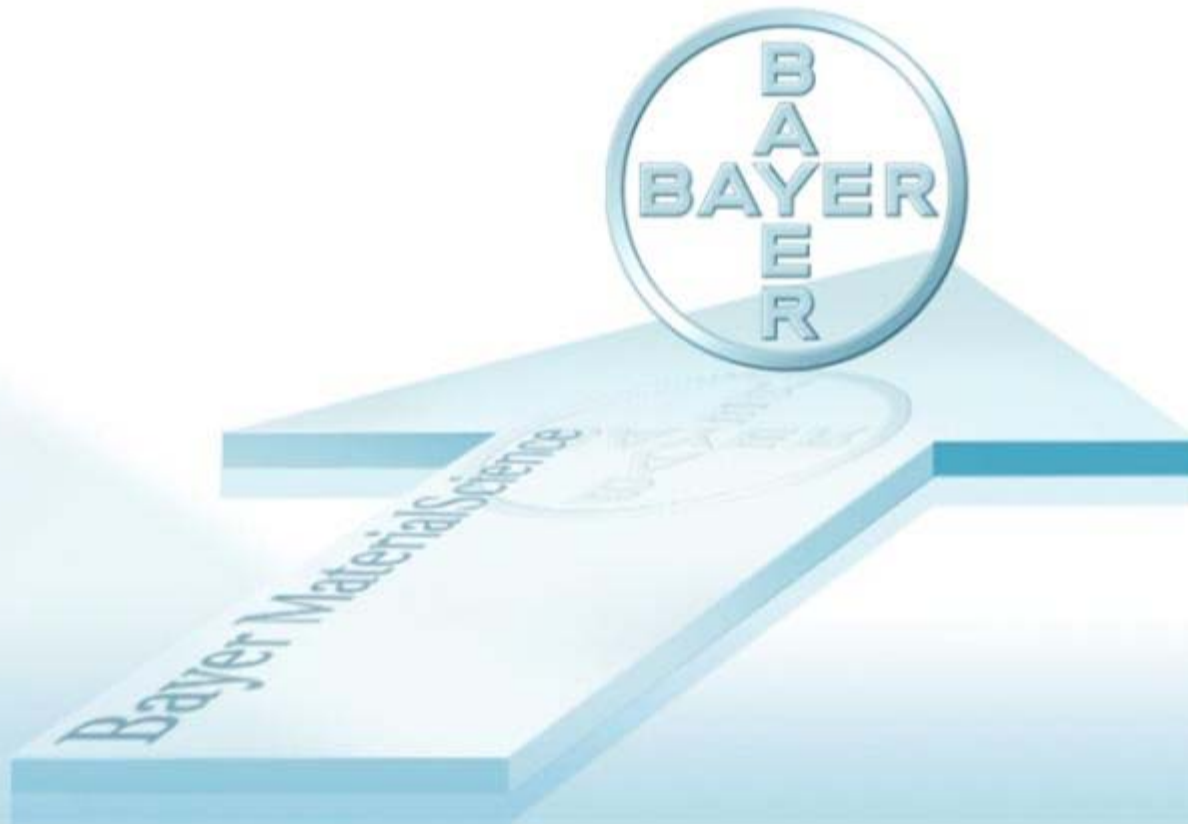
- Flat coatings
 - Black coating close to meeting topcoat specification
 - Gray coatings need reformulation
- Gloss white coatings
 - Physical performance specs matched
 - Gloss is lower than desired
- Qualify to MIL-PRF-81352
 - Light footprint limited to touch up applications
 - Touch up specification
 - Lower gloss requirement ($60^\circ = 80$)



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Thanks for your attention!





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